EPA-PNL-2068

Palmer Hough/DC/USEPA/US

12/21/2012 10:48 PM

To: aicher.rebecca, Barbara Butler, Bill Dunbar, Cara Steiner-Riley, Christopher Hunter, David Allnutt, Glenn Suter, Hanady Kader, Heather Dean, Heidi Nalven, Jason Todd, Jeff Frithsen, Jenny Thomas, Jim Wigington, Joe Ebersole, Judy Smith, Julia McCarthy, Kate Schofield, Marianne Holsman, Mary Thiesing, Michael Szerlog, Palmer Hough, Phil North, Rachel Fertik, Richard Parkin, Sheila Eckman, Tami Fordham

cc

bcc

Subject: Fw: Review of Peer Review

BB Team:

The AK Conservation Foundation had a number of scientists review and provide comments on the Sept Peer Review Report. Attached below are the comments provided by these scientists. You may find these of interest.

-Palmer

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----- Forwarded by Palmer Hough/DC/USEPA/US on 12/22/2012 01:45 AM -----

From: Samuel Snyder <snyder.bristolbay@[redacted]>
To: Palmer Hough/DC/USEPA/US@EPA
Date: 12/21/2012 03:05 PM
Subject: Review of Peer Review

Palmer,

I hope this email finds you doing well. This email is a week later than I had hoped, but better late than never.

In any case, you will find several reviews of the peer review from our team. If you have any questions about them, don't hesitate to reach out.

Hope you have a good and relaxing holiday.

Best,
Sam

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"I shall never look upon a river without urgent consideration of the possibilities of finding fish somewhere in it." Roderick Haig-Brown

Go Green, Keep it on your screen! Think before you print!

Samuel Snyder, PhD
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Peer_Review_Comments_SO'N_19_Dec_2012.pdf

EPA.BBWA.ReviewComments_Maest_21Dec2012.pdf

Comments on Final Peer Review Report_Zamzow_Final.pdf

Comments on Final Peer Review Report - Chambers 4Dec12.pdf

2012_12_18_Wobus_PeerReview_Comments.pdf

From: Sarah O'Neal
To: Palmer Hough, EPA Hough.Palmer@epamail.epa.gov
Cc: Sam Snyder Snyder.bristolbay[redacted] Dave Chambers dchambers@csp2.org; Carol Ann Woody carolw@alaskalife.org

Date: December 17, 2012

Re: Comments on "Final Peer Review Report, External Peer Review of EPA's Draft Document, An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," September 17, 2012

I reviewed approximately the first half of the document paying particular attention to the subjects with which I am most familiar, the fisheries within watersheds near the Bristol Bay region.

p. 8, General reaction
Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

This sentiment is repeated on p. 54, Gordon Reeves:
Any additional analysis could consider using Intrinsic Potential (IP) (Burnett et al. 2007. Ecological Applications 17:66–80), which considers local geomorphic features to estimate the potential of a given stream reach to provide high quality habitat for a given species. The concept, developed for use in the Pacific Northwest (PNW), has been applied successfully for Chinook salmon in the upper Copper River (A. Bidlack, EcoTrust, Cordova, AK., unpublished). The IP model for Chinook salmon from the PNW that was used in the Copper River was modified after discussion with local biologists. Similar modification may be needed for the PNW IP model for coho salmon to be used in Bristol Bay.

Currently, data is not available to estimate the relative magnitude of impacts to salmon habitat from mining in Bristol Bay. While it would be a worthwhile effort to collect such data--and indeed an effort that should have been made by mine proponents during their data collection effort--it simply does not exist. Further, the "intrinsic potential" (IP) model is inappropriate for this use. It is a model that was developed in the Lower 48 to prioritize habitat for restoration in streams with ESA-listed salmon species[1]. It incorporates three parameters: channel gradient, an index of valley width, and mean

[1] Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17(1): 66-80.

annual discharge, thereby unnecessarily over-simplifying natural habitats[2]. It further relies on habitat suitability curves that were developed for salmon species in the Pacific Northwest[1]. Given vastly different temperature regimes and other habitat attributes in Alaska, suitability curves would require additional original research for use in Bristol Bay. The IP model was developed for ESA-listed streams due to the lack of historic data to describe pre-development salmon productivity. However, commercial fishing is the only significant impact to Bristol Bay fisheries presently. Given that, a more direct and appropriate metric to estimate relative magnitude of impacts to the region from mining is productivity (ideally returns per spawner). This type of original research, while ideal, woul take considerable time and funding and would not likely, in the end, change the conclusions of the original draft considerably.

p. 9, General reaction
Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

More or less the same comment is repeated on p. 28 in Dauble's response to Charge Question 1: **As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of nonsalmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay watershed (including the Nushagak River and Kvichak River watersheds) is not described in any detail there or in the main report. Available data on known or perceived ecological interactions among salmonid and resident fish should be included in the assessment.**

The fish assemblage is dominated by sculpin (*Cottus* sp.), which are more than twice as dense as other fish species in headwater streams draining the Pebble deposit (O'Neal and Woody *In prep*). Because of their high abundance and biomass, sculpins are important predators of macroinvertebrates and fish eggs, and important prey to sport fishes and terrestrial wildlife[3]. Sculpin are less mobile than many fish taxa, and are often more

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[2] Agrawal, A., R.S. Schick, E.P. Bjorkstedt, R.G. Szerlong, M.N. Goslin, B.C. Spence, T.H. Williams, and K.M. Burnett. 2005. Predicting the potential for historical coho, Chinook and steelhead habitat in northern California. NOAA Technical Memorandum, NMFS. Santa Cruz, CA. 34 pp.

[3]Poe, T.P., H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the Anerican Fisheries Society 120: 405-420.

Foote, C.J. and G.S. Brown. 1998. Ecological relationship between freshwater sculpins (genus *Cottus*) and beach-spawning sockeye salmon (*Oncorhynchus nerka*) in Iliamna Lake, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 55: 1524-1533 sensitive to stream acidification and metals contamination than species typically used to establish water quality criteria[4]. Sculpin are followed in prevalence by coho salmon and Dolly Varden in headwater streams (O'Neal and Woody *In prep.*). However, little information is available with regard to sculpins role in the ecosystem. Although the subject is worth further investigation, additional evidence regarding sculpin would likely conclude that the impacts in the current draft of the Watershed Assessment are UNDERestimated.

p. 10, General reaction

Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

The following references address the role of surface water/groundwater interactions. Additionally, see report provided by Status Consulting to EPA.

Stanford, J.A. and J.V. Ward. 1988. The hyporheic habitat of river ecosystems. Nature 335:64-66. Ward, J. 1989. The four-dimensional nature of lotic ecosystems. Journal of the North American Benthological Society 8(1): 2-8.

Gilbert, J., M. Dole-Olivier, P. Marmonier, and P. Vervier. 1990. Surface water-groundwater ecotones. Pp. 199-225 in R.J. Naiman and H. Decamps (Eds.). The Ecology and Management of Aquatic-Terrestrial Ecotones. The Parthenon Publishing Group, Carnforth, England.

Dahm C.N., and H.M. Valett. 1996. Hyporheic zones. Pp. 107-119 in F.R. Hauer and G.A. Lamberti (Eds.) Methods in Stream Ecology. Academic Press, San Diego, California.

Hodgens, L.S., S.C. Blumenshine, and J.C. Bednarz. 2004. Great blue heron predation on stocked rainbow trout in an Arkansas tailwater fishery. North American Journal of Fisheries Management 24: 63-75.

Madenjian, C.P., D.W. Hondorp, T.J. Desorcie, and J.D. Holuszko. 2005. Sculpin community dynamics in Lake Michigan. Journal of Great Lakes Research 31: 267-276.

[4] Matuszek, J.E., J. Goodier, and D.L. Wales. 1990. The occurrence of Cyprinidae and other small fish species in relation to pH in Ontario Lakes. Transactions of the American Fisheries Society 119: 850-861.

Maret, T.R. and D.E. MacCoy. 2002. Fish assemblages and environmental variables associated with hard-rock mining in the Coeur d'Alene River Basin, Idaho. Transactions of the American Fisheries Society 131: 865-884.

Woodling, J., S. Brinkman, And S. Albeke. 2002. Acute and chronic toxicity of zinc to the mottled sculpin *Cottus bairdi*. Environmental Toxicology and Chemistry 21: 1922-1926.

Gray, M.A., R.A. Cunjak, and K.R. Munkittrick. 2004. Site fidelity of slimy sculpin (*Cottus cognatus*): insights from stable carbon and nitrogen analysis. Canadian Journal of Fisheries and Aquatic Sciences 61: 1717-1722.

Dubé, M.G., D.L. MacLatchy, J.D. Kieffer, N.E. Glozier, J.M. Culp, and K.J. Cash. 2005. Effects of metal mining effluent on Atlantic salmon (*Salmo salar*) and slimy sculpin (*Cottus cognatus*): using articial streams to assess existing effects and predict future consequences. Science of the Total Environment 343: 135-154.

Besser, J.M., C.A. Mebane, D.R. Mount, C.D. Ivey, J.L. Kunz, I.E. Greer, T.W. May, and C.G. Ingersoll. 2007. Sensitivity of mottled sculpins (*Cottus bairdi*) and rainbow trout (*Oncorhynchus mykiss*) to acute and chronic toxicity of cadmium, copper, and zinc. Environmental Toxicology and Chemistry 26: 1657-1665.

Natsumeda, T. 2007. Movement patterns of Japanese fluvial sculpin *Cottus pollux* in a headwater stream. Transactions of the American Fisheries Society 136: 1769-1777.

Reynolds, J.B. 1997. Ecology of overwintering fishes in Alaskan freshwaters. Pp 281-302 in A.M Milner, M.W. Milner, and M.W. Oswood (Eds.), Freshwaters of Alaska: Ecological Syntheses. Springer-Verlag, New York.

Winter, T.C., J.W. Harvey, O.L. Franke, and W.M. Alley. 1998. Groundwater and surface water – a single resource. US Geological Survey, Circ. 1139. 87 pp.

Power, G., R.S. Brown, and J.G. Imhof. 1999. Groundwater and fish—insights from northern North Anerica. Hydrological Processes 1393): 401-422.

Poole, G., J. Risley, and M. Hicks. 2001. Spatial and temporal patterns of stream temperature (revised). EPA Issue Paper 3, EPA-910-D-01-003. 33 pp.

Poole, G.C., S.J. O'Daniel, K.L. Jones, W.W. Woessner, E.S. Bernhardt, A.M. Helton, J.A. Hancock, P.J. 2002. Human impacts on the stream-groundwater exchange zone. Environmental Management 29(6): 763-781.

Malcolm, I.A., C. Soulsby, A. Youngson, D. Hannah, I. McLaren and A. Thorne. 2004. Hydrological influences on hyporheic water quality: implication for salmon egg survival. Hydrological Processes 18: 1543-1560.

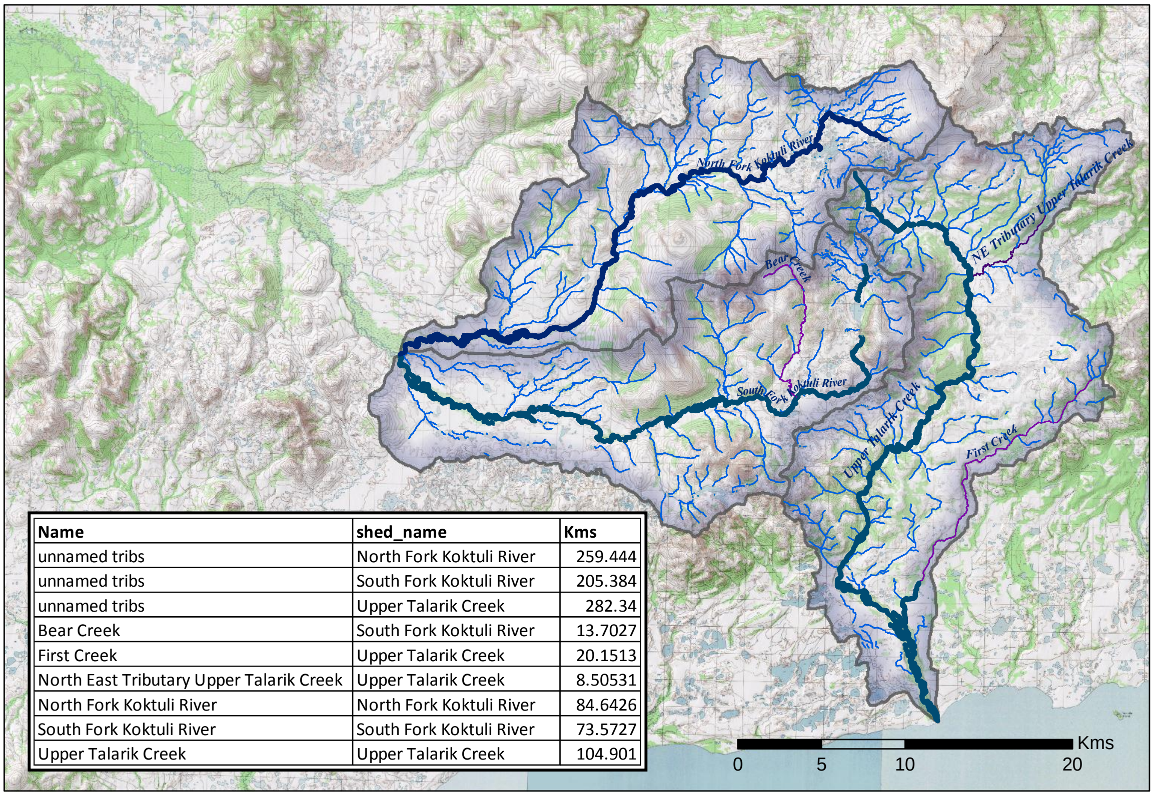
Acuña, V. and K. Tockner. 2008. Surface-subsurface water exchange rates along alluvial river reaches control the thermal patterns in an alpine river network. Freshwater Biology 54(2): 306-320.

Gray, M. A., R. A. Cunjak, and K. R. Munkittrick. 2004. Site fidelity of slimy sculpin (Cottus cognatus): insights from stable carbon and nitrogen analysis. Canadian Journal of Fisheries and Aquatic Sciences **61**:1717-1722.

Stanford, B.R. Boer, and T.J. Beechie. 2008. Hydrologic spiraling: The role of multiple interactive flow paths in stream ecosystems. River Research and Applications 24: 1018-1031.

p. 17, Gordon Reeves: **Much attention is given to "headwater streams" and their ecological importance (p. 5-19 – 5-21). Headwater streams for the area of consideration need to be defined so that appropriateness of the application of the literature can be better judged.**

Headwater streams are generally defined as low order and/or intermittent streams[5]. They compose more than three times the linear stream length in the North and South Fork Koktuli Rivers and Upper Talarik Creek (The Nature Conservancy, unpublished data).



Name	shed_name	Kms
unnamed tribs	North Fork Koktuli River	259.444
unnamed tribs	South Fork Koktuli River	205.384
unnamed tribs	Upper Talarik Creek	282.34
Bear Creek	South Fork Koktuli River	13.7027
First Creek	Upper Talarik Creek	20.1513
North East Tributary Upper Talarik Creek	Upper Talarik Creek	8.50531
North Fork Koktuli River	North Fork Koktuli River	84.6426
South Fork Koktuli River	South Fork Koktuli River	73.5727
Upper Talarik Creek	Upper Talarik Creek	104.901

[5] Meyer, J.L., D.L. Strayer, J.B. Wallace, S.L. Eggert, G.S. Helfman, and N.E. Leonard. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association 43(1): 86-103.

p. 28, Dennis Dauble
Another limitation to the salmon-centric assessment is that risk assessment endpoints, described in Chapter 3 of the main report, do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes of aquatic communities. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. What nutrient levels occur in these stream systems with and without MDN?

A description of major groups of aquatic invertebrates in terms of biomass and seasonal abundance should be included in the main report.

This data has not been the focus of any particular studies, however spawning is most active in late August and early September, so reviewing NDM's and PLP's water chemistry data collected in those months relative to nutrient data collected during the remainder of the year may be informative. Some additional data regarding primary and secondary production is available from Alaska's Natural Heritage Program, which recently completed a report summarizing data collected between 2008 and 2011[6]. Data reported by PLP describing Ephemoptera-Plecoptera-Trichoptera taxa are erroneous, and thus should not be incorporated into the report[7]. Chironomid data, however, is reliable.

p. 30, Roy Stein
Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph). Given our current understanding, general changes likely include more intense precipitation events and increased temperature (and then of course, all that follows from these two changes and as models become more sophisticated, more specific geographically localized impacts could be assessed).

Air temperatures in Western Alaska are predicted to increase by 2-3ºC and precipitation 25-50% by the end of the Century[8].

p. 38, Roy Stein
Given the productivity of salmon from these two river systems (50% of the sockeye salmon in Bristol Bay are produced from these rivers), might there be some thought given to limiting the mining operations to a single watershed, either the Nushagak or the Kvichak (page ES-2)?

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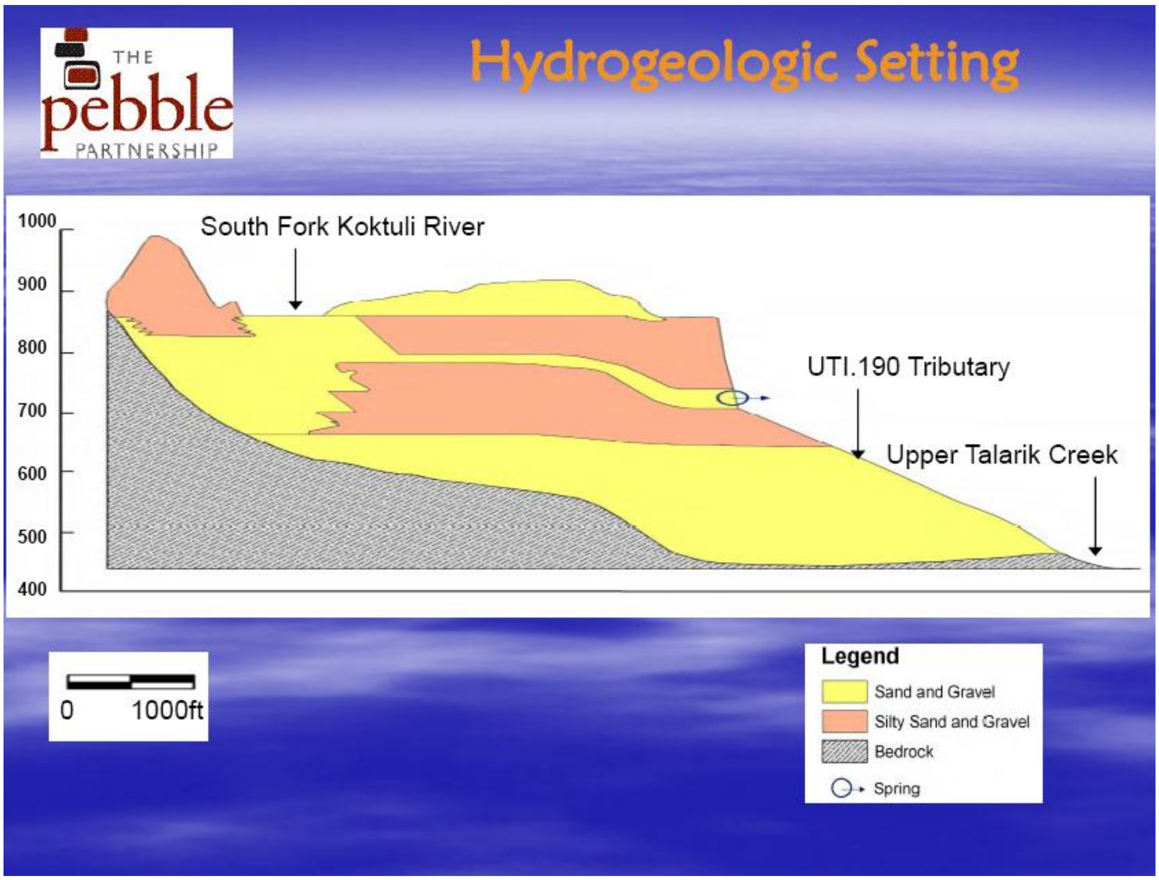
[6] Bogan, D., R. Shaftel, and D. Rinella. 2012. Baseline biological surveys in wadeable streams of the Kvichak and Nushagak watersheds, Bristol Bay, Alaska. Report prepared for Alaska Department of Environmental Conservation by Alaska Natural Heritage Program, University of Alaska Anchorage. 31 pp.

[7] O'Neal, S. 2012. A review of PLP Environmental Baseline Documents: Aquatic macroinvertebrates (Bristol Bay drainages). Available from: http://pebblescience.org/pdfs/FINAL_Macroinvertebrate_Review_11_May_2012.pdf.

[8] Maurer, E. P., L. Brekke, T. Pruitt, and P. B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. EOS, Transactions of the American Geophysical Union **88**:504.

Unfortunately, this is an impossibility due to inter-basin exchange of waters (Figure below)[9] which would prevent isolation of pollutants and other impacts. The highly permeable glacial till, combined with a difference in elevation, allows water to move out of the South Fork Koktuli River in the Nushagak drainage to the Upper Talarik in the Kvichak drainage. Additionally, while the ore body is primarily in the Nushagak drainage, much of the infrastructure (roads, pipeline) would need to pass through the Kvichak drainage in order to reach a proposed shipping port. No other route has been proposed.



p. 75, William Stubblefield
Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD); therefore, direct effects on salmon are even less likely at concentrations in the range of the AWQC.

Indeed, salmonids are not the most sensitive aquatic organisms in the Bristol Bay region to copper. However, relying solely on ambient water quality criteria is likely to overlook both direct and indirect sublethal impacts to salmon from copper exposure. For example, olfactory receptors are indirectly impacted by increases in copper concentrations of 2-20

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9 PLP EBD, 2011

μg/L[10], concentrations which are frequently below water quality standards. Impaired olfaction can interfere with identification of predator, prey, mates, and kin, ultimately leading to decreased survival[11].

In addition to sublethal impacts to salmonids from copper, impacts to more sensitive species may impact salmonids through foodweb effects and other interactions. Studies that document cumulative adverse effects of Cu on productivity of a salmonid food chain are lacking. However, slight increases in Cu above normal background levels and below Alaska AWQ criteria can reduce productivity of key links in aquatic food chains including algae, zooplankton, freshwater mussels, macroinvertebrates, and other fish which can ultimately result in reduced fish growth and reproduction[12].

Copper is one of the most toxic metals to unicellular algae, which form the base of the salmonid food chain. Photosynthetic algae production (*Chlorella* spp.) can decline at just 1.0 – 2 parts per billion (ppb) Cu and photosynthesis can be inhibited at 5.0 to 6.3 ppb[13]. Zooplankton feed on algae and their growth and reproduction are affected by food availability; declines in algae production can cause declines in zooplankton production[14], which implies reduced food for fish that feed on zooplankton.

Zooplankton are the preferred food of juvenile sockeye salmon which rear in lakes one to two years prior to seaward migration. Zooplankton are highly sensitive to acute Cu effects and studies of Cu toxicity in test waters of high hardness show that Cladocera may not be adequately protected by current Alaska AWQ criteria[15]. Freshwater mussels live in sediments and are filter feeders. They are a primary food of humpback whitefish**[16]**, which in turn are both prey for larger fish and a preferred subsistence species in the Kvichak River watershed (Woody and Young in Review) and can impair growth and

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[10] Sandahl, J. F., D. H. Baldwin, J. J. Jenkins, and N. L. Scholz. 2007. A sensory system at the interface between urban stormwater runoff and salmon survival. Environmental science & technology **41**:2998-3004.

Baldwin, D. H., C. P. Tatara, and N. L. Scholz. 2011. Copper-induced olfactory toxicity in salmon and steelhead: Extrapolation across species and rearing environments. Aquatic Toxicology **101**:295-297

[11] McIntyre, J. K., D. H. Baldwin, D. A. Beauchamp, and N. L. Scholz. 2012. Low-level copper exposures increase visibility and vulnerability of juvenile coho salmon to cutthroat trout predators. Ecological Applications **22**:1460-1471.

[12] Wootton, J. Timothy. "The nature and consequences of indirect effects in ecological communities." *Annual Review of Ecology and Systematics* (1994): 443-466.

[13] USEPA (US Environmental Protection Agency). 1980. Ambient water quality criteria for copper. USEPA Report 440/5-80-036. 162 pp.

Franklin NM, Stauber JL, Markich SJ and Lim RP. 2000. pH-dependent toxicity of copper and uranium to a tropical freshwater alga (Chlorella sp.). Aquat. Toxicol. 48: 275–289.

[14] Urabe, J. 1991. Effect of food concentration on growth, reproduction and survivorship of Bosmina longirostris (Cladocera): An experimental study. Freshwater Biology (25)1:1-8.

Müller-Navarra, D and W Lampert. 1996. Seasonal patterns of food limitation in Daphnia galeata: separating food quantity and food quality effects. Journal of Plankton Research.7: 1137-1157.

[15] Bossuyt BTA, Muyssen BTA and Janssen CR. 2005. Relevance of generic and site- specific species sensitivity distributions in the current risk assessment procedures for copper and zinc. Environ. Toxicol. Chem. 24: 470-478.

[16] Brown GE, Smith RJ. 1997. Conspecific skin extracts elicit antipredator responses in juvenile rainbow trout (Oncorhynchus mykiss). Can. J Zool 75:1916–1922.

survival of mussel early life stages showed that growth and survival of mussel early life stages were impaired at *Cu concentrations below Alaska AWQ criteria*[17].

Aquatic insects (i.e., freshwater macroinvertebrates) are a critical component of freshwater ecosystems[18], forming a link between the base of stream foodwebs and top consumers both in aquatic (e.g., fish) and adjacent terrestrial systems (e.g., spiders, birds and bats). Insects process organic matter, influencing stream chemistry, and consume primary producers (algae and other diatoms)[19]. In turn, macroinvertebrates are consumed by fish[19], making insects ultimately responsible for converting plant material into animal tissue in lotic systems. Aquatic insects are important food items for salmon and other fish species, as well as other macroinvertebrates. They comprise the majority of juvenile coho and Chinook salmon diets (up to 80%) as well as Dolly Varden diets (up to 100%) in some rivers[20]. Chironomids, which dominate headwater streams surrounding mining claims, are particularly sensitive to copper, with some genera experience lethal impacts at 10 ppb[21].

Fish species common to the region's waters are also more sensitive to copper than salmon. Arctic grayling alevins and fry experience lethal effects at 2.65 ppb and 9.6 ppb Cu, respectively[22]. Sculpin dominate the biomass of area waters (O'Neal and Woody *in prep*) and are an important component in the foodweb as both consumers as well as prey for larger fish, including sport fish such as rainbow trout. Sculpin are also less mobile than many fish taxa, and are often more sensitive to stream acidification and metals contamination than species typically used to establish water quality criteria[23]. Rainbow

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[17] Wang N, Ingersoll CG, Greer IE, Hardesty DK, Ivey CD, Kunz JL, Brumbaugh WG, Dwyer FJ, Roberts AD, Augspurger T, Kane CM, Neves RJ, and Barnhart MC. 2007c. Contaminant Sensitivity of Freshwater Mussels: Chronic toxicity of copper and ammonia to juvenile freshwater mussels (Unionidae). Environ. Toxicol. Chem. Vol. 26 (10): 2048–2056.

[18] Covich, A.P., M.A. Palmer and T.A. Crowl. 1999. The role of benthic invertebrate species in freshwater ecosystems. BioScience 49(2): 119-127.

[19] Allan, J.D. and M.M. Castillo. 2007. Stream ecology: The structure and function of running waters. 2nd Ed. Springer. Dordrecht, The Netherlands. 436 pp.

[20] Higgs, D.A., J.S. Macdonald, C.D. Levings, and B.S. Dosanjh. 1995. Nutrition and feeding habits in relation to life history stage. *In* C. Groot, L. Margolis, and W.C. Clarke (Eds.). Physiological Ecology of Pacific Salmon. UBC Press, Vancouver, British Columbia. Pp. 159-316.

Eberle, L.C. and J.A. Stanford. 2010. Importance and seasonal availability of terrestrial invertebrates as prey for juvenile salmonids in floodplain spring brooks of the Kol River (Kamchatka, Russian Federation). River Research and Applications 26: 682-694.

[21] Oswood, M.W. 1989. Community structure of benthic invertebrates in interior Alaskan (USA) streams and rivers. Hydrobiologia 172: 97-110.

Bogan, D., D. Rinella and R. Shaftel. 2012. Baseline macroinvertebrate and diatom surveys in wadeable streams of the Kvichak and Nushagak watersheds, Bristol Bay, Alaska. Prepared for The Nature Conservancy. Alaska Natural Heritage Program, University of Alaska Anchorage. 27 pp.

USEPA (US Environmental Protection Agency). 1980. Ambient water quality criteria for copper. USEPA Report 440/5-80-036. 162 pp.

[22] Buhl, KJ and SJ Hamilton. 1990. Comparative toxicology of inorganic contaminants released by placer mining to early life stages of salmonids. Ecotoxicology and Environmental Safety. 20:325-342.

[23] Maret, T. R. and D. E. MacCoy. 2002. Fish Assemblages and Environmental Variables Associated with Hard-Rock Mining in the Coeur d'Alene River Basin, Idaho. Transactions of the American Fisheries Society **131**:865-884.

trout fry experience negative effects of Cu at just 0.1 ppb, and lethal effects at 9.0 ppb Cu[24].

It is important to note that the waters in this area are cleaner and more pure in almost every measurable analyte than is required by hardness-based Alaska Water Quality Criteria. For discharge to reach AWQC standards would be to degrade the water quality through which this food web evolved.

Woodling, J., S. Brinkman, and S. Albeke. 2002. Acute and chronic toxicity of zinc to the mottled sculpin *Cottus bairdi*. Environmental Toxicology and Chemistry **21**:1922-1926

Dubé, M. G., D. L. MacLatchy, J. D. Kieffer, N. E. Glozier, J. M. Culp, and K. J. Cash. 2005. Effects of metal mining effluent on Atlantic salmon (*Salmo salar*) and slimy sculpin (*Cottus cognatus*): using artificial streams to assess existing effects and predict future consequences. Science of The Total Environment **343**:135-154.

[24] USEPA (US Environmental Protection Agency). 1980. Ambient water quality criteria for copper. USEPA Report 440/5-80-036. 162 pp.

Hara, TJ, YMC Law, and S. Macdonald. 1977. Effects of copper and mercury on the olfactory response in rainbow trout, Salmo gairdneri. Journal of the Fishery Research Board of Canada. 33:1568-1573.

Buhl, KJ and SJ Hamilton. 1990. Comparative toxicology of inorganic contaminants released by placer mining to early life stages of salmonids. Ecotoxicology and Environmental Safety. 20:325-342.

Memorandum

To: U.S. Environmental Protection Agency (EPA), Office of Research and Development

From: Ann Maest, PhD, Stratus Consulting Inc.

Date: 12/21/2012

Subject: Comments on Peer Review of EPA's Draft Bristol Bay Watershed Assessment

1. Introduction

This memorandum provides comments on water quality, geochemical, and mitigation measure issues discussed in "Final Peer Review Report, External Peer Review of EPA's Draft Document: An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" (Versar, 2012). The main topic areas that I address are best practice prevention and mitigation measures, failure scenarios, and uncertainties related to the Biotic Ligand Model and the use of water quality standards.

I hope that these comments are useful to EPA as they prepare their final Watershed Assessment.

2. Best Practice Prevention and Mitigation Measures

Mitigation measures were addressed in Charge question 12 to the draft Watershed Assessment peer reviewers (p. 6):

> *Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?*

Many reviewers noted that the discussion of mitigation measures and mine operation in the draft Watershed Assessment needs to move from "good practice" to "best practice." As noted by Dirk van Zyl (p. 23):

> *The main body of the report emphasizes on a number of occasions (such as page 4-1, 4-17) that "Our mine scenario represents current good, but not necessarily best, mining practices."*

An important part of best practices is tailings management, as Dirk van Zyl discusses on p. 40. Other reviewers, including David Atkins, Steve Buckley, Charles Slaughter, John Stednick, and

Roy Stein conclude that the mitigation measures or the no-failure scenarios are not well described (Charge question 3; pp. 45–48).

I agree with the reviewers' comments. To address the many reviewer comments on this topic, I suggest that EPA add a section after Section 4.2 (i.e., a new 4.3, or a part of 4.2) that describes the types of best practice prevention and mitigation measures that could be used in the mine scenario presented in the draft Watershed Assessment. Unfortunately, Appendix I of the draft Watershed Assessment (Conventional Water Quality Mitigation Practices for Mine Design, Construction, Operation, and Closure) does not discuss best practices for mine operation or mitigation and prevention measures, and does not even reference the primary source on the topic used most often by the mining industry (INAP, 2012). I suggest that EPA keep their hypothetical mine plan the same in terms of facilities and extraction methods, and use an approach that closely follows INAP (2012) and Golder Associates (2012; see Chapter 8) to describe best practices. INAP (2012) also includes a table showing whether the best practice methods are proven and where they might not work as well [see Table 6-7: Summary of Prevention and Mitigative Measures and Climate Considerations in INAP (2012)]. Some of the conditions mentioned in the table are relevant to the Pebble area, which has a climate most similar to the Koppen classification D (Continental severe mid-latitude) or E (Polar). Some of the mitigation and prevention measures have not been fully demonstrated in all of the climate types, and EPA could note these limitations in the final Watershed Assessment.

3. Failure Scenarios

Failure modes or scenarios were addressed in Charge questions 3 and 5 (p. 5):

> *EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?*
>
> *Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?*

Some reviewers note that something between "no failure" and "catastrophic failure" should be described that would include events with a higher probability that would result in smaller-scale failures. For example, John Stednick wrote (p. 19):

> *The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures.*

Rather than using only "no-failure" and "failure" scenarios in the risk assessment, a better approach might be to classify and describe the potential environmental effects using the following categories:

- *Effects from presence of mine facilities.* Under the assumed mine scenario in the draft Watershed Assessment, placement of wastes, excavation of the open pit, and mine dewatering would result in the loss of headwater streams and wetlands, as described in portions of Section 4.3 of the draft Watershed Assessment.

- *Failures resulting from lack of adequate characterization.* Failures related to the lack of adequate hydrologic or geochemical characterization are described in detail in Kuipers and Maest (2006), which has now been peer reviewed by EPA. Such failures could involve movement along faults that were not identified before mining began. This failure mode is not currently included in the draft Watershed Assessment, but it has occurred at the Buckhorn Mine in northern Washington State. As noted in my July 23, 2012 comments to EPA on the draft Watershed Assessment, the mine's consultants attributed increases in mine-related contaminants in streams near the Buckhorn Mine to movement of water stored in the underground mine along a large fault. Other characterization failures may include incorrect placement of potentially acid-generating (PAG) waste on the non-PAG waste rock piles and water balance errors.

- *Failures of prevention and mitigation measures.* Even if prevention and mitigation measures are installed and operated properly, they can fail. Examples of prevention and mitigation measure failures that are relevant to the mine scenario in the draft Watershed Assessment include the release of contaminated leachate from failure of the monitoring system (including pumps) and failure of the capture zone. Both could result in the appearance of mine-related contaminants in downgradient groundwater and surface water. The draft Watershed Assessment does, however, describe a water collection and treatment failure in Section 6.3. As described in comments from Cameron Wobus the analysis could be updated using the MIKE SHE hydrologic modeling results described in the Wobus et al. (2012) report, which was recently peer reviewed by EPA. Another important failure mode that could occur but that was not described in the draft Watershed Assessment is a failure of the capture zone created by mine dewatering. Such a failure has occurred at the Buckhorn Mine in northern Washington State ($395,000 fine issued;

http://www.ecy.wa.gov/news/2012/240.html). This type of failure could occur seasonally if groundwater levels rise and overwhelm dewatering efforts; it could be a longer-term failure if the dewatering system does not work well in fractured bedrock.

- *Catastrophic failures.* Two catastrophic failures are described in Sections 6.1 (tailings dam failure) and 6.2 (pipeline failure) of the draft Watershed Assessment. Those descriptions could be moved into the new section describing catastrophic failures in the final report.

The perfect performance of prevention and mitigation measures is not guaranteed (see Kuipers and Maest, 2006). As noted by some of the draft Watershed Assessment peer reviewers, EPA does not currently have a basis to assume that the use of best practices at a new mine will prevent adverse environmental effects (Roy Stein, p. 63):

> *I am discouraged when I understand that history (in the eyes of the mining company) is not a good predictor of the future because technology has taken us so much farther along, reducing risks of whatever failure significantly. In my view, this is a specious argument and one that should be roundly put to bed by the authors of this report. History is indeed the absolute best predictor of the future and technological changes that have occurred since past mines must be absolutely and critically evaluated to determine if indeed risks do go down. This is a serious issue and one that should be addressed with some rigor by the authors.*

In addition, no study has been conducted that demonstrates that newer mines using "best practices" pollute less than current or recently operated mines or than mines using "good" practices. As noted by Dirk van Zyl (p. 40):

> *To my knowledge, there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices, whatever definitions are used for "good" and "best."*

Absent such a study, EPA should assume that the information on failures from recently operated and current mines are representative of failures that could occur at a new mine using best practices. In fact, the burden of proof should be on the operator to demonstrate that current best practices improve environmental performance.

4. Uncertainties Related to the Biotic Ligand Model and the Use of Water Quality Standards

In his general comments (p. 22), William Stubblefield suggests that EPA conduct additional research to "*improve our understanding of copper toxicity and to ensure that the regulatory standards are, in fact, appropriate for their intended use*" and resolve the uncertainty mentioned in the draft Watershed Assessment about the protectiveness of the biotic ligand model (BLM) for species of concern in Bristol Bay. He also lists areas of additional research, including investigating the toxicity of metal mixtures and the sensitivity of salmon species of concern in Bristol Bay (p. 70).

I agree that the research identified could be helpful, and we are currently in the planning phase of conducting some of the testing recommended in the peer review document. However, I do not believe that EPA needs to conduct this research before the Watershed Assessment is finalized. At the end of Section 5.3.2.2 in the draft Watershed Assessment, EPA discusses some of the uncertainties associated with the BLM. In addition to those listed in Section 5.3.2.2, another uncertainty associated with BLM is its use in low-hardness waters. We are currently evaluating this issue (Morris et al., 2012a, 2012b; Appendix A).

Because of the uncertainties associated with the use of the BLM at the Pebble site, EPA could complete their watershed assessment by relying on, or at least reflecting, Alaska's existing water quality criteria. The draft Watershed Assessment appears to rely almost exclusively on the BLM-based criteria.[1] For example, EPA calculates acute and chronic copper criteria for each watershed in Table 5-18 of the draft Watershed Assessment, yet there is no similar table for the existing State criteria (they are mentioned once in the text on p. 5-53). For the final Watershed Assessment, EPA could create a table comparing background copper and dissolved organic carbon concentrations and hardness values in each drainage against BLM and State criteria. The table could also include the percentage of the analyses in each drainage that show exceedences of each criterion. Showing mean values and ranges, ideally at several distinct locations, would address many of the reviewers' comments that request more information on the temporal and spatial variability of water quality parameters is needed in the final Watershed Assessment (see, e.g., comments from John Stednick, pp. 30 and 55, and Dennis Dauble, p. 68).

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1. The BLM-based criteria are exceeded in some Pebble site waters at some times, as noted by Paul Whitney on p. 50. Most of these locations are in headwater reaches, yet highly sensitive fish and macroinvertebrate species are thriving in headwater locations, as noted on p. 5-16 of the draft Watershed Assessment.

References

Golder Associates. 2012. New Liberty Gold Mine (NLGM) EIA, Section D: Geochemical Risk Assessment Report. June. Available: http://www.golder.com/bw/en/modules.php?name = Pages&sp_id = 1493. Accessed December 10, 2012.

INAP. 2012. Chapter 6. Prevention and Mitigation. Section 6.6: Overview of Best Practice Methods. The International Network for Acid Prevention. GARD Guide. Available: http://www.gardguide.com/index.php/Chapter_6#6.6_Overview_of_Best_Practice_Methods. Accessed December 10, 2012.

Kuipers, J.R and A.S. Maest. 2006. Comparison of Predicted and Actual Water Quality at Hardrock Mines: The Reliability of Predictions in Environmental Impact Statements. K.A. MacHardy and G. Lawson (contributing authors). Prepared for Earthworks, Washington, DC. Available: http://www.earthworksaction.org/publications.cfm?pubID = 211. Accessed December 13, 2012.

Morris, J. A. Maest, A. Craven, and J. Lipton. 2012a. The Biotic Ligand Model: Unresolved scientific issues and site- and species-specific effects on predicted Cu toxicity. U.S. Environmental Protection Agency, Hard Rock Mining Conference: Advancing Solutions for a New Legacy, Denver, CO, April 3-5, 2012.

Morris, J. A. Maest, A. Craven, and J. Lipton. 2012b. Site-specific Issues with Applying the BLM to Evaluate Cu Toxicity: Overestimation of Cu-DOC Complexation and Model Anomalies in Low Hardness Waters. Society for Environmental Toxicology and Chemistry: 33rd annual meeting, Long Beach, CA, November 11-15.

Versar. 2012. Final Peer Review Report, External Peer Review of EPA's Draft Document: An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska. Prepared for the U.S. Environmental Protection Agency, National Center for Environmental Assessment by Versar, Inc., Springfield, VA.

Wobus, C.W., R. Prucha, A. Maest, and D. Albert. 2012. Potential Hydrologic and Water Quality Alteration from Large-scale Mining of the Pebble Deposit in Bristol Bay, Alaska. Prepared for The Nature Conservancy, October.

A. Copies of Morris et al., 2012a, 2012b Abstracts

The Biotic Ligand Model: Unresolved scientific issues and site- and species-specific effects on predicted Cu toxicity

Jeff Morris[1], Ann Maest[1], Alison Craven[2], and Josh Lipton[1]
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Topic: Water Quality, Water Balance, Water Management, Water Treatment.

Oral presentation requested.

The EPA has approved use of the Biotic Ligand Model (BLM) to calculate site-specific water quality criteria. Although the BLM is an important advance that considers all major-element chemistry, in a number of situations the BLM appears to be under protective of sensitive aquatic organisms, particularly salmonids. The issues discussed relate to the WHAM V model and the biotic ligand binding constants used in the BLM.

At hardness values <20 mg L^{-1} as $CaCO_3$, the BLM predicts lower Cu, Zn, and Cd toxicity to rainbow trout than at somewhat higher hardness values. The effect is more pronounced with increasing dissolved organic carbon (DOC) concentrations but is noticeable at DOC values as low as 1 mg L^{-1}. The lower predicted toxicity appears to be related to modeled metal binding between the gill and DOC. At very low hardness values, the BLM predicts that Cu and other metals will preferentially bind with DOC, and modeled LC_{50} values decrease with increasing hardness. At higher hardness values, the LC_{50} is predicted to rise by ~4 or 5 μg Cu L^{-1} for each ~ 20-mg L^{-1} increase in hardness. There is no empirical evidence to suggest that aquatic biota are more tolerant of metal concentrations at low hardness values, and the hardness-based equations do not produce this peculiarity. A number of headwater streams around the country have low-hardness waters, and use of the BLM at those sites should proceed with caution.

The log K value of the gill, which controls Cu binding to the gill, is set at 7.4 for Cu and rainbow trout in the BLM. No values are currently included in the model for other salmonid species. Plots of Cu LC_{50} and gill log K values show that a gill log K of 7.4 is close to the inflection point for predicted toxicity, and even small changes in gill log K can produce large changes in predicted copper toxicity. The uncertainty in gill log K values should be explored, including the extent to which they change with different salmonid species.

The Biotic Ligand Model (BLM) was used to estimate concentrations of free Cu (Cu^{2+}) in site water near the Pebble deposit in Alaska and to predict the toxicity of Cu^{2+} to rainbow trout. Visual MINTEQ was also used to predict Cu^{2+} concentrations using conditional log K values derived from actual site waters. The BLM predicted considerably lower free Cu concentrations under modeled site conditions. The discrepancy could be reconciled by decreasing DOC input values to the BLM by ~7 times (actual stream value was 2.17 mg L^{-1}). Other researchers have suggested that inputting one-half the measured DOC concentrations to the BLM yields a better fit with fish toxicity data in some cases. These findings and the issues discussed above suggest that the BLM appears to apply higher net Cu-dissolved organic matter (DOM) binding strengths across a range of Cu:DOM ratios and water qualities found in many site waters.

Presentation Type:
Platform

Track:
Aquatic Toxicology and Ecology

Session:
Fate and Effects of Metals: Aquatic Biological Perspective

Abstract Title:
Site-specific issues with applying the BLM to evaluate Cu toxicity: overestimation of Cu-DOC complexation and model anomalies in low hardness waters

Authors:
Jeffrey Morris[1], Ann Maest[1], Alison Craven[2], and Joshua Lipton[1]

1. Stratus Consulting Inc., Boulder, CO. 2. University of Colorado-Boulder, Chemistry and Biochemistry, Boulder, CO

Abstract:

The Biotic Ligand Model (BLM) was used to estimate concentrations of Cu^{2+} in site waters in Alaska and to predict the toxicity of copper to rainbow trout. Visual MINTEQ was also used to predict Cu^{2+} concentrations using conditional log K values for Cu^{2+}-dissolved organic matter (DOM) binding derived from the same site waters over a range of total copper concentrations. The BLM predicted considerably lower Cu^{2+} concentrations than our empirical data when the total copper concentrations were greater than 1 µg L^{-1} (2×10^{-8} M) under modeled site conditions. The discrepancy could be reconciled by decreasing the dissolved organic carbon (DOC) input values to the BLM by ~7 times (actual stream value was 2.17 mg C L^{-1}). Other researchers have suggested that inputting one-half the measured DOC concentrations to the BLM yields a better fit with fish toxicity data in some cases. These findings suggest that the BLM appears to apply stronger net Cu^{2+}- DOM binding across a range of Cu:DOM ratios and water qualities found in many site waters, which could result in an under-prediction of copper toxicity.

Additionally, the BLM applies a log K value of 7.4 for the strength of copper binding to the gill (biotic ligand) for rainbow trout. Plots of total copper LC_{50} and gill log K values show that a gill log K of 7.4 is close to the inflection point for predicted toxicity, and even small changes in gill log K can produce large changes in predicted copper toxicity.

Finally, at hardness values <20 mg L^{-1} as $CaCO_3$, the BLM predicts lower Cu toxicity to rainbow trout than at somewhat higher hardness values. The lower predicted toxicity appears to be related to differences in modeled metal binding affinities between the gill and DOC. At very low hardness values (~5 mg L^{-1} as $CaCO_3$), the BLM predicts that copper will preferentially bind with DOC, and modeled LC_{50} values decrease with increasing hardness (e.g., 5-20 mg L^{-1} as $CaCO_3$). At higher hardness values (e.g., >25 mg L^{-1} as $CaCO_3$), the LC_{50} is predicted to rise by ~4 or 5 µg Cu L^{-1} for each ~ 20-mg L^{-1} increase in hardness. There is no empirical evidence to suggest that aquatic biota are more tolerant of metal concentrations at low hardness values, and the hardness-based water quality criteria equations do not produce this peculiarity. A number of headwater streams around the country have low-hardness waters and use of the BLM at those sites should proceed with caution.

From: Kendra Zamzow, PhD
To: Sam Snyder Snyder.bristolbay@gmail.com;
Cc: Dave Chambers dchambers@csp2.org

Date: December 14, 2012

Re: Comments on "Final Peer Review Report, External Peer Review of EPA's Draft Document, An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," September 17, 2012

To Whom It May Concern:
The area with which I am most familiar, the surface water quality within watersheds near the Bristol Bay region, was discussed, but mine water treatment was not – I agree with several reviewers that this deficiency should be addressed in the Final EPA Bristol Bay Watershed Assessment. Although I agree with peer panel reviewers on that point, I have concerns regarding specific statements in the final peer review report.

Re Question 2
Several reviewers felt a wider range of mine sizes (smaller mine to full development of mining district) should be examined. However, *"The question then becomes what size mine is feasible from a technical and economic point of view" (Atkins, pg 35).*

Atkins (and others) suggest analysis of a mine in the 50th percentile of global mine sizes (~250 million tons). I would suggest that an ecological risk analysis on such a small mine is unnecessary until and unless it is determined what economic conditions would allow such a mine to be feasible. The realistic minimum mine size will be constrained by the cost of infrastructure (roads, power, port), estimated at $4.7 billion, [1] and the costs to operate, maintain, and close the mine. It is unrealistic to choose a minimum size mine for analysis based on the size of mines in globally; it must be bounded by the economics of paying back the infrastructure investment. Economic scenarios have been outlined in the Northern Dynasty commissioned NI-43-101 report.[2] In the report, the "investor case" of a 2 billion ton mine is based on rapid return on investment.

Re Question 2 (pg 39, van Zyl)
"Mining companies typically make investment decisions for periods of 20 to 30 years. It is seldom, if ever, that a new investment will be made based on a 78 year mine life…. It is also unlikely that environmental regulatory agencies will consider issuing a permit, including closure plans, etc. for a 78-year project. Furthermore, even if the mine ultimately continues for 78 years, it is certain that the operating and environmental control technologies and societal expectations will change in that period and therefore the elements used by EPA for the maximum size hypothetical mine will certainly not be valid for such a long mine life. It is therefore my conclusion that assuming the development of a 2 billion tonne ore body is realistic, but that assuming development of a 6.8 billion tonne ore body, using static technology assumptions, is not."

Regardless of the phased permitting structure, a biological risk assessment needs to consider the full risks to the watershed and salmon given the ore body. In fact, the point made in the quote above serves to illustrate the failure of the permitting system to work in the context of mines that could potentially last

[1] Ghaffari, H., Morrison, R.S., Deruijeter, M.A., Živković, A., Hantelmann, T., Ramsey, D. and Cowie, S. 2011. Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop (A Tetra Tech Company), Vancouver, BC. Chapter 1, Section 1.11.2
[2] Ibid, Chapter 1, Section 1.11 and Chapter 18

longer than the Alaska state government has existed, and the difficulty of assessing comprehensive and cumulative impacts over long periods of time through the permitting system. While it is appropriate to bound the minimum mine size by the economics of return on investment, the maximum mine size needs to consider the potential ecological damage that full exploitation of measured and indicated resources, currently known to be 6.5 billion tons.[3] The ore body is "unbounded" in several directions, indicating the risks are likely to be greater than assessed, not less. Additionally, hypothetical impact-lessening technologies that have not been developed cannot be assessed.

Re Question 2 (pg 42, Weber-Scannell)
"The Environmental Assessment seems a bit premature in making an assessment of the potential for acid rock drainage (ARD) or metals leaching (ML)."

There is ample evidence from PLP testing and from weathered Cominco core samples that acid drainage will develop, and that neutral drainage will leach selenium.[4] Pre-tertiary waste rock samples and tailings tested overwhelmingly potentially acid generating (PAG), with leachate elevated in copper, cadmium, and zinc.[5] Pyritic tails, at neutral pH, leached nickel, selenium, silver, and zinc, all of which negatively impact fish.[6] Tertiary waste rock samples tested primarily non-acid generating (NAG), with some PAG material,[7] with samples leaching selenium in concentrations above water quality criteria and some samples leaching molybdenum, arsenic, and copper above water quality criteria.[8]

Re Question 3 (pg 49, Weber-Scannell)
"Pit water quality depends on how the pit is developed, what reclamation will occur, if reclamation will be concurrent with mining, and what kinds of water treatment will be used."

The EPA scenario of pit lake water quality (Section 4.3.8.1) – initially acid due to runoff from sulfide-rock pit walls, reduced as the pit lake fills – is reasonable. Long term pit lake water quality is difficult to predict. Oxidation of pit walls during the decades of mining and the decades of pit water rebound will cause acid runoff into the pit lake; additionally, the results from subaqueous column tests suggest that waste rock submerged in the pit lake could produce acid for some period of time.[9] This can be managed with addition of lime, as has been done at the Sleeper Pit Lake in Nevada.[10] However, because runoff will contain both divalent metals (copper, iron, etc.) that will precipitate with lime treatment and metalloids (selenium, molybdenum) that will not precipitate, the water quality of the lake is almost certain to be of poorer quality than that of natural streams. Unless evaporation exceeds or equals incoming flows, pit lake water will flow out of the pit after it has filled. This water will require treatment. Alaska does not have a law preventing the development of mines that require perpetual water treatment, and Alaska's regulatory history makes development of such mines a certainty, regardless of ecosystem risk.

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[3] Ghaffari et al. 2011. Chapter 1, Section 1.1.4
[4] PLP. 2011. Pebble Project Environmental Baseline Document 2004 through 2008. Chapter 11, Appendix 11L, 11M; also Maest, A. 2012. Comments on US EPA Draft Bristol Bay Watershed Assessment (July 23) Appendix A, pp 9-14 for concise summary of acid drainage and metal leaching potential.
[5] Ibid, pH - Figures 11-13, 1-17, 11-58; copper, cadmium, and zinc leachate Figure 11-25 to 11-27, 11-30
[6] Ibid, Appendix 11L, 11M
[7] Ibid, Figures 11-33, 11-37
[8] Ibid, Figures 11-41, 11-42.
[9] Ibid, Appendix 11I, Chart 1
[10] It should be noted that a pit wall slump at Sleeper Lake caused pH to drop and metal loadings to rise as acid rock deposited in the lake. While this was controlled with further additions of lime, it illustrates one of the risks of perpetual care. *Southwest Hydrology*. 2002. Precious metals pit lakes: controls on eventual water quality. September/October.

Re Question 3 (pg 50, Whitney)
"*I do not agree with the assessment's critical question – whether or not effects are observed at these low levels (page 5-57, Exposure-Response Data from Analogous Sites, second sentence). If effects are observed at background concentrations, it seems unreasonable to ask for an even lower benchmark than background concentrations."*

My interpretation of EPA's assessment is that the legal standards (Alaska water quality criteria, AWQC) might not be protective. Background concentrations of most analytes in natural waters in the Bristol Bay headwaters are lower (cleaner) than hardness-based AWQC. EPA can emphasize this with information from my report and the EBD. The EPA also did not clearly state that mixing zones are not allowed in salmon spawning waters under current Alaska regulations,[11] and therefore discharge would, at a minimum, need to meet AWQC at the point of discharge.

Re Question 4 (pg 58, van Zyl)
"If all the PAG material will be removed from the surface, as stated in the scenario in Chapter 4, and the NAG will not generate acid drainage, then it is difficult to understand why the waste rock piles and waste rock used for construction (supposedly all NAG at this stage) would be the major source of 'routinely generated wastewater.'"

Acid drainage is not the only potential threat to water quality; neutral pH release of toxic metals is also a risk. Pebble East ore lies beneath several hundred feet of un-economic rock. This rock will almost certainly be utilized in facility construction – roads, pads, tailings dams, etc. In shake-flask, humidity cell, and rain water leach tests (MWMP)[12], tertiary rock from Pebble West released high concentrations of selenium under neutral pH.[13] If testing reports similar results for Pebble East tertiary rock, then runoff from waste rock piles and construction rock will routinely generate wastewater that will require collection and treatment. This will also need to be considered when planning for *in perpetuity* closure.

Re Question 6 (pg 70, Stubblefield)
"Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD); therefore, direct effects on salmon are even less likely at concentrations in the range of the AWQC."

Current AWQC are hardness-based and do not require use of the copper Biotic Ligand Model (BLM), which would characterize the toxic concentration risk to specific species of aquatic life. However, very few of the fish species in the Pebble stream are incorporated into the copper BLM, and this increases uncertainty about the applicability of the BLM to Pebble waters. Until these uncertainties are resolved, the current AWQC should be used. Even if BLM-based criteria were applied, the risk needs to be placed in the context of the current, un-impacted water quality. The natural water quality is extraordinarily good, with many samples reporting metal concentrations, even copper, an order of magnitude below AWQC (copper was commonly detected near 0.2 ug/L). Therefore attaining AWQC will degrade waters from their present condition (Dauble notes this in his response to Question 6, pp 67-68 of the Final Peer Review Report); that is, discharge will bring about a "new normal" downstream. It's not known whether a new normal itself would adversely affect salmon or their food chain, but potentially even small leaks and spills added to the new normal of lower quality water could have a greater impact.

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[11] Alaska Administrative Code, 18AAC 70.240
[12] MWMP = meteoric water mobility procedure
[13] PLP. 2011. Pebble Project Environmental Baseline Document 2004 through 2008. Chapter 11, Figure 11-42

Re Question 8 (pg 80, van Zyl)
"If the concentrate is submerged under water in relatively slow flowing streams then very little long-term release of the copper will occur, as the water does not contain sufficient oxygen to allow for sulfide oxidation. It is only when the concentrate is transported to locations above the water level that oxidation and release of metals will occur."

In theory, this statement may be correct. However, the site-specific context should be considered. The area generally has shallow streams with groundwater-surface water exchange that can affect oxidation: 1) at downwelling locations where reaches may go dry, 2) at upwelling locations where oxygen upwells into streams, and 3) wind-mixing. In addition, during spring floods, mine-related sediments would be deposited on the flood plain where they would be exposed to oxygen throughout most of the year. These are dynamic systems with fluctuating flows and volumes. Where streams lie on a slope, they are unlikely to be slow-flowing. Where they are not on a slope, they may feed wetland complexes, which are generally a mix of submerged and exposed landforms. Additionally, sulfide oxidation is not the only threat to streams receiving a slurry concentrate spill; slow-moving streams will be affected by the smothering of gravels, as mentioned by the Watershed Assessment.

Thank you for considering these remarks.

Sincerely,

Kendra Zamzow

Kendra Zamzow, PhD

Date: December 4, 2012

Re: Comments on "Final Peer Review Report, External Peer Review of EPA's Draft Document, An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," September 17, 2012

From: David M. Chambers

The Final Peer Review Report contains a long list of detailed comments from a well-qualified group of experts who participated on the Peer Review Panel. Although most of the comments address issues with which I have only peripheral familiarity, some of the comments address areas in which I am qualified to comment. With some of these comments I have a somewhat different position than that expressed by the Peer Reviewers, and I would like the opportunity to explain why I believe these comments might be interpreted differently.

The comments which I would like to call to your attention are copied in italics below.

Peer Review Report, p. 40:

> *"It is also inconceivable to me that the company will not follow "best mining practices" in the design and development of such a mine."*

In designing and regulating a mine companies and regulatory agencies typically follow some, but by no means all, "best practices". While it is possible that designs in a final mining-permit could be different from initial mine design proposals, it is by no means "inconceivable" that plans will go forward with little or no changes.

For example liners can be considered best practice for tailings ponds. In Alaska lined, or partially lined tailings facilities are utilized at Pogo, Greens Creek, and Nixon Fork. Liners were not required at Red Dog (highly acid generating waste), Rock Creek (cyanide), Fort Knox (cyanide, some neutral drainage contaminants), and Kensington.

There are several examples from the Pebble Project that are illustrative. At the present the Pebble Limited Partnership (PLP) has stated they are not considering a lined tailings pond.[2] A liner at Pebble not likely to be required by state or federal regulatory authorities when permits are considered because of the significant costs involved, and because precedent has not required a liner for tailings ponds for this type of mine either nationally or in Alaska. Red Dog, which would be the closest analog to Pebble in Alaska (base metal mine with potentially acid generating waste), is not required to have a lined tailings pond.

Another example is the design seismic event that is proposed by PLP engineers. Best-practice would be to use the maximum credible earthquake as the design seismic event, but use of a lesser seismic event has been proposed by PLP.[3]

Dam design type is a third example. The best-practice dam design would be downstream-type, but the proposed designs have all been a hybrid centerline-type design.

Finally, PLP has not used best practice during its own exploration. Best practice in mineral exploration drilling would dictate lined pond-sumps for drill cuttings and drill fluids. Not only do drilling muds contain contaminants like barium and hydrocarbons, but the target minerals for exploration are sulfides,

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[2] "A geomembrane face liner will be connected to the plinth and extended up the embankment face." Ghaffari et al., Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, February 17, 2011, p. 356.

[3] "Long Term Risks of Tailings Dam Failure," David M Chambers and Bretwood Higman, October, 2011

which when brought to the oxidizing environment at the surface pose a danger of heavy metal contamination. Lined drill sumps are not being utilized for the exploration drilling at Pebble, the largest exploration project in Alaska, which now constitutes over 1000 holes.[4]

Frankly, to claim that best-practice design would always be followed by either mine designers or by regulators is not realistic.

Peer Review Report, p. 40:

> *"Filtered dry stack tailings can be considered as a realistic option, even for mines with higher production rates."*

Dry stack are very unlikely to be proposed by the developer at Pebble because of the significant increase in cost associated with this tailings placement method. I am not aware of a single example in a regulatory jurisdiction where the regulatory agency has required a mine developer to use dry stack tailings.

Peer Review Report, p. 40:

> *"Flotation of remaining sulfides in the tailings before deposition is also a realistic option for mines; it has been done successfully at the Thompson Creek Mine in Idaho for the last 18 plus years."*

Pyrite flotation of is certainly technologically viable, but is another example of a best-practice that is seldom done at mines, almost always because of the additional cost involved.

Pyrite floatation is being utilized at Thompson Creek because the cycloned tailings sands used to construct early stages of the dam also concentrated pyrite in the coarse sand fraction, and have already caused an intractable long term acid generation problem. A pyrite floatation circuit was later installed so that the coarse sand fraction of the tailings could continue to be used for dam construction after the pyrite is removed. At this point in time there really is no other alternative for dam construction material. And, even with 'clean' sands on top of the contaminated sand material used for the initial stages of dam construction, there will still be a long term acid generation problem because the sands affected must remain unsaturated (and exposed to oxygen) to insure the long term seismic stability of the dam.

Peer Review Report, p. 49:

> *"If the mining company is still managing the site, then they will have responsibilities under all Federal and State Regulations and the dire picture painted by the EPA Assessment should not come to pass."*

Organizational 'responsibility' for a large mining project is often a problematic management assignment. Metal prices rise and fall; mining companies are bought, sold, and merged; mines change hands. Companies provide bonds to the State to ensure mine closure will occur if there is a bankruptcy. Bonding may or may not be sufficient to close a mine. As of 2012 Alaska has 10 operating, proposed, or closed large mines (Pebble, Donlin, Fort Knox, Red Dog, Greens Creek, Kensington, Pogo, Nixon Fork, Rock Creek, and Illinois Creek mines). Of these one closed before reaching actual operating status (Rock Creek), and one went into bankruptcy with inadequate bonding to cover mine closure (Illinois Creek).

To put it another way, 20% of Alaska large mines have closed prematurely, and 10% have gone into bankruptcy with inadequate reclamation & closure bonding. While Alaska bond calculation procedures have been updated, it would not be prudent to presume that a bankruptcy with accompanying bond deficiencies could never happen again.

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[4] "Water Quality at Pebble Prospect Drill Rig #6, South Fork Koktuli River, Bristol Bay, Alaska, 22-23 Oct. 2011," Woody, et. al., Final report July 9, 2012.

Peer Review Report, p. 80:

> *"If the concentrate (due to a pipeline spill) is submerged under water in relatively slow flowing streams then very little long-term release of the copper will occur, as the water does not contain sufficient oxygen to allow for sulfide oxidation."*

This statement is not supported by fact. It is well known that sulfide minerals moving as sediment downstream channels creates significant contamination problems when that material is mobilized and exposed due to normal fluvial processes. For example, low flow, even in a slow moving stream, could periodically expose sulfide minerals to oxidation, and the salts would be mobilized during the next storm event, spring freshet, etc. These systems are dynamic, subject to freeze-thaw conditions and fluctuating volumes and flows.

Peer Review Report, p. 81:

> *"Because of the dire consequences of a failure in this highly sensitive and unique environment, it would be necessary to employ state of the art methods for tailings management and go 'beyond compliance' when designing and constructing this facility. This may include employing methods that are novel, incur significant additional cost for construction, and lead to a more stable and lower maintenance facility in the long term, such as dry stack or paste rock tailings (blending waste rock in with tailings in the impoundment to provide extra geotechnical stability)."*

Dry stack tailings could provide additional geotechnical stability, paste tailings would not. In order to gain "additional" geotechnical stability, the tailings would require mechanical compaction. Without compaction the tailings are still subject to resaturation and mobilization under seismic loading or an uncontrolled hydrologic event.

The primary use of paste tailings has been in underground mining backfill, although in the past decade paste tailings have been more widely utilized in surface mining operations. The primary advantage of paste tailings is the recycling/recovery of process water, which will not be of significant relevance at Pebble.[5] Paste tailings do not have the inherent structural advantages of dry-compacted tailings.

To date the PLP has discussed only conventional tailings disposal behind a tailings dam. Use of "state-of-the-art methods" have seldom been required by a regulatory agency for an Alaska mine, and would likely be incorporated only if recommended by the mine proponent – which is not the case to date at Pebble.

Peer Review Report, pp. 81-82:

> *"The assessment deemed that it was "not possible" to determine how far the initial slurry deposition would extend, how far re-suspended sediments would travel, and how long erosion processes would continue. It seems that information from other mine closure sites could be used by assessment authors to infer effect by analogy. The statement alluding to potential sediment run out distance at the bottom of page 4-56 of the main report should be included in the summary of effects. This is an important point."*

There is good empirical information on tailings runout distance in: Rico et. al., "Floods from tailings dam failures, Journal of Hazardous Materials, 2008." See Figures 2 & 3 on Rico, page 82.

Peer Review Report, pp. 84:

> *"A significant improvement in tailings management is the implementation of an Independent Tailings Dam Review Board (ITRB) for large mining projects (Morgenstern, 2010). ... I expect that a tailings review board will also be used for the Pebble Mine and the behavior of a tailings management facility*

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[5] "Paste: A Maturing Technology," Simon Walker, Engineering & Mining Journal Features, European Editor, downloaded at http://www.e-mj.com/index.php/features/1151-paste-a-maturing-technology, Nov12

designed and operated under these conditions will be more representative of the potential failure likelihoods expected for such a facility."

Unfortunately there is no requirement, hence no guarantee, that an independent review board will be utilized for tailings management oversight at Pebble. Regardless, Pebble is not the only mine that is likely for the Bristol Bay region if the Pebble mine is constructed, since the transportation infrastructure that would accompany Pebble could facilitate the development of additional mines in the area. It is likely these secondary mines would not face the same level of scrutiny that Pebble would.

In addition, even with regulatory oversight there are many examples of the dam construction-type changing in later stages of a mining project. This is perfectly illustrated by the Fort Knox Mine in Alaska where the all but the final stage of tailings dam construction was downstream. However, the final dam lift is upstream - the type of construction most susceptible to seismic instability.

Peer Review Report, pp. 84:

"I would consider the assumption that a release of 20% of the tailings material for the Pebble mine scenario is on the high side, even during operations."

Data presented in "Floods from tailings dam failures," M. Rico, G. Benito, A. D´ıez-Herrero, Journal of Hazardous Materials, 2008" would support the interpretation that approximately 20% would be an "average" value for tailings release during a tailings dam failure (see Rico, Figure 4, p. 83).

Note that the information presented in the Rico paper is based on actual tailings dam failure data.

Peer Review Report, pp. 84:

"In the case of the Aznalcóllar Tailings Dam failure in Spain, all the released tailings downstream of the mine were removed. While such a removal action will impact parts of the watershed, it will help to recover the area faster than leaving all the tailings in place and will also reduce the longer-term impacts on downstream water quality. I therefore disagree with the assumption on p. 6-2 that "the assessment assumes that significant amounts of tailings would remain in the receiving watershed for some time and remediation may not occur at all."

Data on the success of tailings spill cleanup is lacking. It was estimated by Boliden, the company that owned the failed dam, that 97-98% of the spilled tailings were recovered in the cleanup.[6] However, it was also noted that "The clean-up left a completely barren landscape without ground vegetation, except for some large trees that could be saved."[7]

Tailings cleanup in the Pebble area that requires a "completely barren landscape without ground vegetation" would likely pose a different set of problems in southwest Alaska than those in Spain, where there is an existing road system that could be used for cleanup access, and where the climate is much warmer and dryer.

Peer Review Report, pp. 84-85:

"Box 6-1 provides "background on relevant analogous tailings spill sites" and three historic sites are used as analogs. These are not realistic analogs, as they all relate to historic mining under completely different scenarios. While the material historically released in these streams were from base metal mines, the circumstances of their release, especially in the case of the Clark Fork and the Coeur

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[6] "The tailings pond failure at the Aznalcóllar mine, Spain," N. Eriksson, Boliden Environmental Staff, Aznalcóllar, Spain, P. Adamek, Mine Environmental Consultant, Sevilla, Spain, Paper prepared for the Sixth International Symposium in Environmental Issues and Waste Management in Energy and Mineral Production, Calgary, Alberta, Canada, 30 May – 2 June, 2000, p. 6.
[7] Ibid, p. 4.

D'Alene Rivers, were very different. Long-term uncontrolled releases occurred in these river systems due to regulatory circumstances or historically acceptable practices that differ significantly from those in the 21st Century."

Although the release mechanisms for the Clark Fork and Coeur d'Alene Rivers are different than for a tailings dam failure, the issue at hand is not the release mechanism, but:

(1) how the material released affected aquatic organisms in the river; and,
(2) how difficult, and whether, a cleanup of this released material was possible.

The examples utilized in the Watershed Assessment address these critical issues, and to ignore the lessons available from these examples, even though the release mechanism is different, would be irresponsible.

Thank you for the opportunity to comment on this report.

Sincerely:

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Memorandum

To: U.S. Environmental Protection Agency (EPA), Office of Research and Development

From: Cameron Wobus, PhD, Stratus Consulting Inc.

Date: 12/18/2012

Subject: Comments on Peer Review of EPA's Bristol Bay Watershed Assessment

1. Introduction

This memorandum provides comments on hydrologic issues discussed in "Final Peer Review Report, External Peer Review of EPA's Draft Document: An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" (Versar, 2012). My comments below are focused on ways that EPA could leverage additional datasets to address some of the issues raised by the reviewers. As I was the lead author of the report "Potential Hydrologic and Water Quality Alteration from Large-scale Mining of the Pebble Deposit in Bristol Bay, Alaska" (Wobus et al., 2012), the majority of my suggestions relate to ways that our hydrologic modeling results could be used to respond to reviewer comments; however, I provide other suggestions where appropriate.

My comments below are organized by topic. In each case, I quote key passages from the peer reviewers in italics, and my comments follow in plain type. I hope that these comments are useful to EPA as they prepare their final watershed assessment.

2. Emphasis on Catastrophic vs. Smaller-scale Failures

A number of reviewers pointed out that the draft Watershed Assessment emphasizes risk from the failure of a tailings storage facility (TSF) dam, and places relatively little emphasis on risks related to other, smaller-scale failures (e.g., failures in water collection and treatment systems). Below are examples of such comments:

Peer Review Report, p. 7:

> *Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.*

Peer Review Report, p. 24:

> *Too much emphasis was placed on effects of catastrophic failures, such as failure of a tailings dam or pipeline, and too little emphasis on the need to identify and control seepage water, run-off from PAG (potentially acid generating) and NAG (not acid generating) waste rock areas, and water treatment.*

I agree with both reviewers here. Although the analysis of "failure mode" is a necessary part of the Watershed Assessment, I agree that the current draft overemphasizes these events relative to the daily operations of a mine that could also adversely affect water quantity, water quality, and habitat. By emphasizing these large-scale failures, the report may also inadvertently make it appear that the mine poses *less* risk to the ecosystem than may be the case, because it may be easier for readers to discount low-probability events such as tailings dam failures.

In the report prepared by Stratus Consulting for The Nature Conservancy (Wobus et al., 2012), we modeled leachate migration through groundwater resulting from short-lived leachate collection system failures. The results of this analysis indicate that even a short-term failure in a waste rock leachate collection system, or the escape of small amounts of leachate around such systems, could result in acute toxicity in downstream waters within a period of days to weeks. Such failures are substantially more likely than a tailings dam failure during the operating life of a mine, and are even more likely under a "perpetual treatment" scenario. Including the results of this analysis in the final Watershed Assessment would be a relatively simple way to answer some of the reviewers' concerns regarding overemphasis on catastrophic failure events.

Also in regard to catastrophic events, one of the reviewers noted that a sediment transport model could be employed to provide a better estimate of the nature and extent of downstream impacts from a tailings dam failure.

Peer Review Report, p. 82:

> *Physical consequences of TSF dam failure are fairly portrayed. I would only suggest that effects of initial sediment deposition and long-term remobilization and redeposition would extend beyond the spatial and temporal limits of the modeling used in the Assessment. Employing advanced eco-hydraulic modeling tools such as MIKE-11, MIKE-SHE (DHI, Copenhagen), and consultation with state-of-art practitioners (IAHR-International Association for Hydraulics Research, UI Center for Ecohydraulics Research, and others), along with improved high-resolution input data such as LIDAR survey of the complete Kvichak and Koktuli/Nushagak systems, would allow a more complete estimate of potential hydrologic and sedimentation (and consequently biotic) consequences of TSF dam failure for the entire river system, headwaters to Bristol Bay.*

I agree with the reviewer that a more detailed estimate of downstream impacts from a TSF failure *could* be attained using hydraulic modeling software such as MIKE-11/MIKE-SHE. If EPA determines that such an analysis would be useful, Stratus Consulting could build upon our existing MIKE-SHE model to develop these simulations to incorporate consideration of deposition and long-term remobilization of tailings.

However, EPA should also consider whether such an analysis would substantially strengthen the draft Watershed Assessment. Release of tailings from a TSF failure would under almost any circumstances pose an unacceptable adverse impact to the watershed, and it may be that a detailed hydrologic model is not required to support this assertion. If EPA can provide sufficient documentation from previous TSF failures that the effects on downstream habitat would be catastrophic, then the overall risk would still depend primarily on the probability of a TSF failure. Addressing reviewers' other concerns regarding an improved estimate of TSF failure probability may therefore be a better use of EPA resources.

3. Scale of the Mine Scenario

One of the challenges faced by EPA in developing the draft Watershed Assessment was the task of evaluating the environmental impacts of a potential mine before a detailed mine plan is released. The challenges of this task were pointed out by some of the reviewers; however, I do not believe that the uncertainties presented by this issue are as problematic as some of the reviewers have suggested. In particular, I do not think that the concerns described below about the scale of the mine scenario are well founded.

Peer Review Report, p. 13:

> *The main deficiency in the assessment is that it uses only two hypothetical mine scenarios to bracket the potential impacts of mining activities on the ecological resources in the watershed. Both of these mine scenarios are larger than the 90th percentile of all porphyry copper deposits in the world. In order to properly assess the potential effects of mining activities, in the absence of any specific mining proposal, a minimum mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits would be more appropriate.*

I disagree with this comment. If the Watershed Assessment were developed in part to examine the impacts of developing the Pebble deposit, then it is clearly appropriate to use a mine scenario whose size is commensurate with the size of the resource. According to Northern Dynasty Minerals, the Pebble deposit is the largest undeveloped copper deposit and the largest undeveloped gold deposit in the world (NDM, 2012), and it seems very unlikely that the Pebble Limited Partnership (PLP) would invest in the infrastructure needed to develop the resource and then leave a large fraction of it in the ground. Because the resource is large relative to other deposits in the world, it is appropriate for the Watershed Assessment to use a mine scenario that is similar in size.

4. Climate Change

Several reviewers highlighted the fact that the draft Watershed Assessment did not emphasize climate change as much as it should have. Climate change could become an important consideration in designing culverts along the access road, estimating the probable maximum flood for design of the tailings dam, and evaluating the impacts of mine development on streamflows. Below are some of the peer-review comments regarding climate change.

Peer Review Report, p. 13:

> *A major component that is missing from the report is consideration of the potential impacts of climate change. Climate change is identified as a factor in the conceptual model of potential habitat and water quality effects associated with mine accidents and catastrophic failures (Fig. 32D). However, I believe that it is a key factor that will have influence in all aspects of the assessment, not just failures and natural disturbance events (Fig. 3-2C).*

Peer Review Report, p. 30:

> *Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph).*

Peer Review Report, p. 55:

> *Climate variability is recognized as a game changer. What are the potential future scenarios for temperature and precipitation changes in southwest Alaska, and how will these scenarios affect the water balance? How will climate change affect the availability of water for mine operations, including processing and potable uses?*

I agree that climate change should be considered more explicitly in the revised Watershed Assessment. However, analyzing climate change effects on mine development requires a robust hydrologic model of the system. For example, even if the percent change in peak precipitation from climate change could be perfectly predicted, it cannot be assumed that this would cause an equal percent change in streamflow, because there are complex surface water-groundwater interactions at the Pebble site. Thus it may be difficult for EPA to address this comment without a detailed hydrologic model of the system.

The hydrologic model that we developed for the Pebble Mine has been shown to capture the major components of the hydrologic system, including the timing and magnitude of streamflow peaks and the location of groundwater upwelling zones (e.g., Wobus et al., 2012). Because this calibrated model already links the atmospheric, surface water, and groundwater systems, exploring the effects of climate change on both baseline and mine-impacted conditions would be a relatively straightforward task. If EPA decides to pursue a more extensive analysis of climate change impacts, Stratus Consulting may be able to assist with that effort.

5. Groundwater-surface Water Connectivity

The reviewers noted that the draft Watershed Assessment describes the importance of groundwater-surface water interactions, yet does not contain a detailed analysis of how these interactions relate to mine development.

Peer Review Report, p. 14:

> *The assessment identifies the interconnectivity of groundwater, surface water, and fish habitat as being a major component of the quality of the fishery in the watershed yet puts relatively little effort into the analysis of the detailed relationships between groundwater, surface water, water quality, and fish habitat, even though this is likely the most important factor in assessing the potential impacts of mining activities on the fisheries in the watershed.*

Peer Review Report, p. 27:

> *…the descriptions of the relationship between landforms, streams, and surface water and the interaction with groundwater are mentioned as very important to fish in the watersheds, yet there is insufficient detail to assess these interactions and consequently, the characterization of these resources is weak.*

Because of the extensive interactions between surface water and groundwater, estimating the overall hydrologic impacts of a mine on the ecosystem requires a model that accounts for these interactions. As described above, the model developed by Stratus Consulting (Wobus et al., 2012) describes these interactions at a sufficient level of detail to examine these effects. The results of our analysis illustrate the integrated response of the hydrologic system to mine-related perturbations, including the magnitude and extent of reductions in streamflow downstream from the mine site. The predictions for flow reductions due to a mine are broadly similar to the predictions contained in the draft Watershed Assessment, and could be cited as support for the more general calculations conducted by EPA.

Our model also qualitatively matches the location of groundwater upwelling zones (e.g., Wobus et al., 2012, Figure 8). Although not included in our report, it may be possible to create impact maps showing potential changes in groundwater upwelling under the mining scenario. This analysis has not yet been completed, but could be a relatively straightforward way to address these reviewer concerns.

References

NDM. 2012. The Pebble Project: The Future of U.S. Mining and Metals. Northern Dynasty Minerals. Available: http://www.northerndynastyminerals.com/i/pdf/ndm/NDM_Presentation_Dec2012.pdf. Accessed December 11, 2012.

Versar. 2012. Final Peer Review Report, External Peer Review of EPA's Draft Document: An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska. Prepared for the U.S. Environmental Protection Agency, National Center for Environmental Assessment by Versar, Inc., Springfield, VA.

Wobus, C.W., R. Prucha, A. Maest, and D. Albert. 2012. Potential Hydrologic and Water Quality Alteration from Large-scale Mining of the Pebble Deposit in Bristol Bay, Alaska. Prepared for The Nature Conservancy. October.